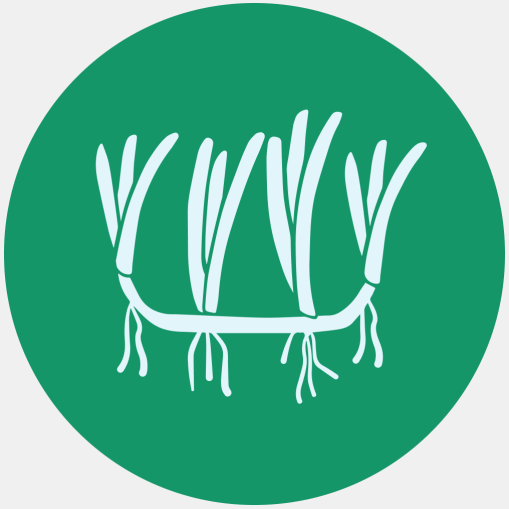
The Global Ocean Observing System

GCOS

Version: 2.1 March 2025

Essential Ocean Variable Specification Sheet

Seagrass cover and composition



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EOV Specification Sheet curated by:

Biology and Ecosystems Panel

The Global Ocean Observing System

GCOS

DETAILED INFORMATION ON HOW TO READ THE SPECIFICATION SHEET CAN BE FOUND IN THIS GUIDE

Background and justification

Why is seagrass cover and composition an Essential Ocean Variable (EOV)?

Seagrass cover and composition is recognized as an Essential Ocean Variable (EOV) because it provides vital insights into ocean health, biodiversity, and climate resilience. These ecosystems are important habitats and play a key role in supporting marine biodiversity, sustaining fisheries, stabilising coastlines, and filtering pollutants, delivering critical benefits to coastal communities around the world (Nordlund et al 2016). Moreover, their noteworthy capacity for "blue carbon" sequestration and storage significantly contributes to climate change mitigation efforts (UNEP, 2020). Monitoring and assessing seagrass cover and composition allow for tracking environmental quality and ecosystem dynamics at global to local scales (Duffy et al. 2019). These insights inform conservation strategies, promote sustainable fisheries, and guide policy development aimed at fostering resilient coastal ecosystems.

Seagrass can be assessed and monitored using several methods, such as in-water surveys, remote sensing, and citizen science, which together enable reliable data collection on its cover, composition, and extent. This should be supported by standardized data collection protocols in combination with standardised data handling. Moreover, regular monitoring is crucial for detecting changes over time. These efforts enhance our ability to model and manage seagrass ecosystems and the associated benefits that support society.

Integration with Global Observation Frameworks

The Global Climate Observing System (GCOS) developed the Essential Climate Variable (ECV) framework to define necessary observations for monitoring Earth's climate (Bojinski et al., 2014). Some EOVs, including ocean physics, biogeochemistry, and biology/ecosystems variables (GCOS, 2022a; GCOS, 2022b), are also ECVs.

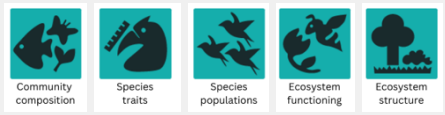
The Essential Biodiversity Variables (EBVs) defined and curated by the Group on Earth Observations Biodiversity Observation Network (GEO BON) complement the GOOS biological and ecosystem (BioEco) EOVs (Miloslavich et al., 2018; Muller-Karger et al., 2018; Bax et al., 2019). The EOVs are measured (primary observations), while EBVs are not measured, they are derived from direct measurements of BioEco EOVs and other observations. Furthermore, the EBVs take the form of time series of BioEco EOVs and other observations, or model results, at a location or over an area. Thus, EOVs may be seen as the building blocks for GEO BON EBVs. The EOVs can be used to synthesise the EBVs as time series of BioEco EOV sub-variables at one location, or as time series of gridded, mapped, or modelled EOVs (Jetz et al., 2019).

The GOOS Biology and Ecosystems Panel collaborates with the Physics and Climate and Biogeochemistry Panels to advance EOVs, advocating for the need for biological observations, information management, and applications. GOOS, MBON, GEO BON, and OBIS work together to standardise guidelines and data management for EOVs, EBVs, and ECVs.

Current observing networks and coordination

Diverse networks and communities are collecting observations of biology and ecosystems EOVs at different scales and in different regions. An initial baseline survey conducted in 2019/20 identified 203 active, long-term (>5 years) observing programs systematically sampling marine life. These programs spanned about 7% of the ocean surface area, mostly concentrated in coastal regions of the United States, Canada, Europe, and Australia (Satterthwaite et al 2021). This information can be found in the GOOS BioEco Metadata Portal, which is continually updated. To consult the latest information, please visit: https://bioeco.goosocean.org

Contributes to (please click on the symbol for more information):

EBV: 

ECV: 

SDG: 

CBD: 

Other: 

1. EOV information

ESSENTIAL OCEAN VARIABLE (EOV)	Seagrass cover and composition
DEFINITION	The areal extent, cover, and species composition of the submerged plants that form the foundation of seagrass habitats and ecosystems
EOV SUB-VARIABLES - key measurements that are used to estimate the EOV	Seagrass percent cover Seagrass species composition Seagrass areal extent
SUPPORTING VARIABLES - other measurements that are useful to provide scale or context to the sub-variables of the EOV	Environmental: water depth, water clarity, water temperature, salinity, sediment characteristics (grain size distribution, bulk density, organic carbon content), nutrient concentrations (NO3, PO4, etc.), pH, dissolved oxygen concentration, land runoff, fishing pressure, coastal development, tourism pressure, surrounding habitats
	EOV related: seagrass shoot length, seagrass canopy height, seagrass shoot density, seagrass (above- and/or below-ground) biomass, epiphytic algae cover and/or biomass, seagrass productivity, seagrass elemental nutrient content, seagrass ash rate and seagrass dry weight
DERIVED PRODUCTS - outputs calculated from the EOV and sub-variables, often in combination with the supporting variables	Global and regional seagrass distribution, seagrass diversity metrics, ecosystem resilience (representing ecosystem state, recovery capacity), carbon storage/sequestration, essential habitat for species of conservation Interest, fish, etc

2. Phenomena to observe - what we want to observe with this EOV

This section presents examples of priority phenomena for GOOS that can be (partly) characterised by this EOV's sub-variables. This list is not exhaustive but serves to provide general suggestions on how observation efforts can structure their planning and implementation.

The GOOS application area(s) the phenomena are relevant for are depicted as follows: Climate  , ocean health  , operational services 

PHENOMENA TO OBSERVE		Habitat status and trends 	Carbon stock and sequestration trends (estimated) 	Changes in species composition 
PHENOMENA EXTENT	HORIZONTAL	local, regional, global	local, regional, global	local, regional, global
	VERTICAL	0 – 100 m	0 – 100 m	0 – 100 m
	TEMPORAL	Seasonal to decadal	Decadal	Weeks to year
RESOLUTION TO OBSERVE PHENOMENA	HORIZONTAL	10 - 1000 m	10 - 1000 m	10 - 1000 m
	VERTICAL	NA	NA	NA
	TEMPORAL	Seasonal to annual	Seasonal to decadal	Seasonal to decadal
SIGNAL TO CAPTURE		>25% change in cover and/or species lost or gained and/or >20% change areal extent	>20% change areal extent and/or >25% change in cover and/or species lost or gained.	species lost or gained
SUB-VARIABLES NEEDED TO MEASURE		percent cover, species composition, areal extent	areal extent, percent cover, species composition	species composition, percent cover, areal extent
SUPPORTING VARIABLES NEEDED		Water clarity	Carbon and emission factors from IPCC (literature-based numbers), Sediment characteristics (esp organic carbon), Carbon sequestration rates from the literature (ref in prep)	

3. GOOS Observing Specifications or Requirements

This section outlines ideal measurements for an optimal observing system for this Essential Ocean Variable (EOV). It offers guidance on creating a long-term system to observe key phenomena related to the EOV. These values are not mandatory, and no single system is expected to meet these specifications. Instead, the combined efforts of various observing systems should aim to meet these goals. Observations at different scales are also valuable contributions to global ocean observation if shared openly.

EOV	Seagrass cover and composition							
PHENOMENA	Habitat status and trends, carbon stock and sequestration trends (estimated), changes in species composition							
EOV SUB-VARIABLE	Seagrass percent cover			**DEFINITION**		The percent of substrate covered by seagrass plants, measured in a defined sample area (%)		
	Resolution			**Timeliness**	**Uncertainty Measurement**	**Stability**	**Sampling approach**	**References**
	Spatial Horizontal	**Spatial Vertical**	**Temporal**					
IDEAL	<1 m	NA	Seasonal		<10% cover		In situ measurements in defined areas (e.g. quadrats) estimate the cover of seagrass in total and/or by species, to the nearest % possible (minimum: in Braun-Blanquet categories of seagrass total)	Braun-Blanquet cover categories Fourqurean et al. 2001 Point counts Protocol Cover and density Kenworthy, W.J., et al. 1993.
DESIRABLE	< 1 m	NA	Annual		10-20% cover			
MINIMUM	< 5 m	NA	Decadal		10-40% cover			

EOV SUB-VARIABLE	Seagrass species composition				DEFINITION		Seagrass species present	
	Resolution			Timelines s	Uncertainty Measurement	Stability	Sampling approach	References
	Spatial Horizontal	Spatial Vertical	Temporal					
IDEAL	<1m	NA	Seasonal		ID to species level		Record the presence of a seagrass species and the location. Minimum: closest possible functional/morphological categories)	
DESIRABLE	<1m	NA	Annual					
MINIMUM	<5m	NA	5 year		Functional/ morphological categories			Kilminster et al., 2015

EOV SUB-VARIABLE	Seagrass areal extent				DEFINITION		The horizontal spatial extent of seagrass	
	Resolution			Timeliness	Uncertainty Measurement	Stability	Sampling approach	References
	Spatial Horizontal	Spatial Vertical	Temporal					
IDEAL	<1*1m (pixel size)		Seasonal, and after extreme events. Sample during the same month		5%		Ideal and desirable: Acquire imagery and apply image classification techniques. Minimum: Create polygons of seagrass meadows using GPS-enabled devices (i.e. smartphone, handheld GPS unit) by walking, swimming or using a boat.	
DESIRABLE	<10*10m (pixel size)		Annual, and after extreme events. Sample during the same season.		10%			
MINIMUM	<30*30m (pixel size)		Decadal		+/- 5m radius			

4. Observing approach, platforms and technologies

This table provides examples of approaches and technologies used to collect this EOV to help observe priority phenomena

APPROACH / PLATFORM	Fixed Point: diver survey or other	Fixed Point: diver survey or other	Remote sensing: satellite
EOV SUB-VARIABLE(S) MEASURED	percent cover, species composition	species composition	areal extent
TECHNIQUE / SENSOR TYPE	Quadrat based surveys, incl. drop camera, photoquadrat	Point observation	Satellite observations
SUGGESTED METHODS AND BEST PRACTICES	Kenworthy, W.J., et al. 1993, species composition - SeagrassSpotter.org, Althaus et al., 2015; Kilminster et al., 2015, den Hartog 1970, Pixel classification - Roelfsema et al 2014 Calibration standards - Foden, 2007		Dierssen et al 2021 Poursanidis et al., 2021 Trinh et al., 2023
SUPPORTING VARIABLES MEASURED	water depth		surrounding habitats

APPROACH / PLATFORM	Remote sensing: other	Fixed-point: other	Fixed Point: other
EOV SUB-VARIABLE(S) MEASURED	areal extent	areal extent, percent cover, species composition	areal extent
TECHNIQUE / SENSOR TYPE	aircraft or aerial drone (cameras with optical sensors, RGB, multi-spectral or hyperspectral, bathymetry lidar)	Remotely operated vehicle (camera), including video transects	GPS-enabled devices for seagrass polygon
RECOMMENDED METHODS AND BEST PRACTICES	UNEP 2020	Roelfsema et al 2015a	
SUPPORTING VARIABLES MEASURED	surrounding habitats	surrounding habitats	surrounding habitats

APPROACH / PLATFORM	Remote sensing: acoustics	Ship based: other Fixed point: other	
EOV SUB-VARIABLE(S) MEASURED	areal extent	species composition	
TECHNIQUE / SENSOR TYPE	vessel mounted (sidescan sonars, single- and/or multibeam)	eDNA	
RECOMMENDED METHODS AND BEST PRACTICES			
SUPPORTING VARIABLES MEASURED	water depth		

5. Data and information management

Access to data and information is at the core of an ocean observing system. This section provides essential information on how to contribute data to the GOOS

GOOS approach to data management is aligned with open data and FAIR (Findable, Accessible, Interoperable, Reusable)[1] practices. All EOV data and information is valuable, thus effective data management practices are essential to ensure it remains accessible and (re)usable for future generations.

In this section you will be directed to resources that explain how you can contribute data to global ocean observing and ensure your data and information is accessible, interoperable and sustained. This resource has instructions for different scenarios: an individual submitting data, or existing data centres connecting to the system.

Please follow these practices carefully, as BioEco EOV data FAIRness relies on compliance with these guidelines.

Before proceeding, please note these important points:

1. As a **minimum**, you must ensure information describing your EOV data (i.e. metadata) are visible in the Ocean Data and Information System (ODIS)[2]. Regardless of where the actual data is stored, evidence of its existence must be findable within ODIS.
2. BioEco EOV data is successfully managed if it is discoverable in the **GOOS BioEco Portal.** The BioEco Portal is the central point of access and coordination of BioEco EOV observing programmes. Data visible in ODIS will automatically be visible in the BioEco Portal and vice versa.

3. If data is published to OBIS[3], it will also be visible in ODIS and the BioEco Portal. You do not need to also add it elsewhere, unless there is extra information you would like to include.

The main data management steps are as follow:

1. Become discoverable: ensure the data producers (e.g., organisation, programme, project, etc.) and datasets are visible in ODIS
2. Prepare the required metadata about the data producer and the datasets
3. Publish EOV data (e.g. OBIS)
4. Verify discoverability in ODIS

Not all steps may be relevant for you, but **Step 1 is the minimum required** to ensure your data contributes to EOVs. .

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[1] Wilkinson et al. 2016 https://doi.org/10.1038/sdata.2016.18
[2] ODIS, part of IOC-UNESCO's International Oceanographic Data and Information Exchange (IODE), is a global federation of data systems sharing interoperable (meta)data about holdings, services, and other resources to enhance cross-domain data accessibility.
[3] OBIS is a global biodiversity database and IOC-UNESCO IODE component, connecting +30 nodes, +1000 institutions, and 99 countries, interoperating with other major biodiversity hubs like GBIF and makes data visible in ODIS as an ODIS node.

TO CONTRIBUTE DATA AND METADATA TO THE GLOBAL OBSERVING SYSTEM, PLEASE GO TO: https://iobis.github.io/eov-data-management/

Figure 2. Map of OBIS Nodes. See https://obis.org/contact/ for a complete list.

Contact the OBIS Secretariat (helpdesk@obis.org) for help setting up your data workflows. To publish BioEco EOV data from systems like NCEI or ERDDAP to OBIS, consider becoming an OBIS node or collaborating with one. The OBIS Secretariat can help guide you through the process of becoming a Node, or connect you with an appropriate OBIS node (Figure 2).

Help Resources

- EOV Metadata Submission tool: https://eovmetadata.obis.org/

ODIS

- General help https://book.odis.org/index.html
- Connecting to ODIS https://book.odis.org/gettingStarted.html
- ODIS Catalogue of Sources: https://catalogue.odis.org/
- Ocean Info Hub: https://oceaninfohub.org/
- Schema.org framework https://schema.org/

OBIS

- OBIS Manual: https://manual.obis.org/
- OBIS YouTube data formatting and publishing videos: https://www.youtube.com/playlist?list=PLlgUwSvpCFS4TS7ZN0fhByj_3EBZ5lXbF
- Darwin Core term reference list: https://dwc.tdwg.org/terms/
- WoRMS taxonomy: https://www.marinespecies.org/
- Spreadsheet template generator https://www.nordatanet.no/aen/template-generator/config%3DDarwin%20Core
- BioData Guide with example code for transforming datasets to DwC: https://ioos.github.io/bio_data_guide/

GOOS BioEco Portal

- Documentation https://iobis.github.io/bioeco-docs/
- Access https://bioeco.goosocean.org/

Seagrass cover and composition data schema

The data schema consists of a standardised template and vocabulary for organising seagrass data and metadata to facilitate efficient comparisons and inclusion in public data repositories. It is aligned with OBIS and GBIF.

Metadata. includes all the requirements stated above, with the dataset needing to include a title, citation (which can be autogenerated on submission), contact person or organisation that curates the resource, and an abstract. Ideally, the data set should also have information on data ownership, a data use license, and project and funding information.

Data schema. The data schema uses the Darwin Core OBIS-ENV-DATA schema (De Pooter et al., 2017). The format used by OBIS organizes the data into three tables, which can be submitted as CSV files. These tables include:

Event table - describes the sampling events that produced the seagrass and associated data.

Occurrence table - Lists the species (scientificName) of organism(s) recorded from the sampling event, including seagrasses, fulfilling the species composition sub-variable of the seagrass EOV, as well the names of any other organisms sampled

Extended-measurement-or-fact (EMoF) table - Provides a place to record other ecological and environmental information related to the species observed in the occurrence table, including the sub-variables percent cover and areal extent of the seagrass EOV, as well as any supporting variables measured.

The data schema can be downloaded here.

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Acronyms and Abbreviations

CBD: Convention on Biological Diversity

C-GRASS: Coordinated Research Assessment of Seagrass Systems, Working Group 158 of the Scientific Committee for Oceanic Research (SCOR).

EBV: Essential Biodiversity Variables

ECV: Essential Climate Variables

EML: Ecological Metadata Language

EMoF: Extended Measurement or Fact

EOV: Essential Ocean Variables

ERDDAP: Environmental Research Division Data Access Program

FAIR: findable, accessible, interoperable, and reusable

GBF: Global Biodiversity Framework

GBIF: Global Biodiversity Information Facility

GCOS: Global Climate Observing System

GEO BON: Group on Earth Observations Biodiversity Observation Network

GOOS: Global Ocean Observing System

IOC: Intergovernmental Oceanographic Commission

IOCCP: International Ocean Carbon Coordination Project

IODE: International Oceanographic Data and Information Exchange

IPCC: Intergovernmental Panel on Climate Change

MBON: Marine Biodiversity Observation Network

NCEI: National Centres for Environmental Information

OBIS: Ocean Biodiversity Information System

ODIS: Ocean Data Information System

OCG: Observation Coordination Group

OOPC: Ocean Observations Physics and Climate Panel

SDG: Sustainable Development Goals

UNFCCC: United Nations Framework Convention on Climate Change

UNEP: United Nations Environment Programme

Glossary of terms

Derived products: outputs calculated from the EOV and sub-variables, often in combination with the supporting variables, that contribute to evaluating change in phenomena. For example, evaporation can be determined from sea surface temperature measurements; air-sea fluxes of CO2 can be derived from inorganic carbon EOV; fish stock productivity can be determined from fish abundance.

Indicators: An indicator can be defined as a 'measure based on verifiable data that conveys information about more than just itself'. This means that indicators are purpose dependent - the interpretation or meaning given to the data depends on the purpose or issue of concern. (BIP definition)

Measurement Uncertainty: the parameter, associated with the result of a measurement, that characterises the dispersion of the values that could reasonably be attributed to the measurand (GUM)1. It includes all contributions to the uncertainty, expressed in units of 2 standard deviations, unless stated otherwise

Phenomena: properties (e.g., of a species such as distribution), processes (e.g., of the ocean such as surface ocean heat flux), or events (e.g., such as algal blooms) that have distinct spatial and temporal scales, and when observed, inform evaluations of ocean state and ocean change

Stability: The change in bias over time. Stability is quoted per decade.

Supporting variables: other measurements that are useful to provide scale or context to the sub-variables of the EOV (e.g., pressure measurements to provide information on the depth at which subsurface currents are estimated, sea temperature to understand dissolved inorganic carbon, water turbidity to support estimations of hard coral cover).

Sub-variables: key measurements that are used to estimate the EOV (e.g., counts of individuals to provide an estimate of species abundance (such as fish, mammals, seabirds or turtles), partial pressure of carbon dioxide (pCO_2)to estimate ocean inorganic carbon, or wave height to estimate sea state).

Timeliness: The time expectation for availability of data measured from the data acquisition time.

Seagrass areal extent: Area in km2 occupied by seagrass meadow within spatial boundaries of a specified area

Seagrass percent cover: Proportion of substrate in a sample area that is covered (substrate not visible) by seagrass

Seagrass species composition: contribution of each seagrass species or functional group to seagrass abundance and/or extent

Seagrass canopy height: Median vertical distance from the sediment surface to the highest reach of seagrass leaves in the water column

Seagrass shoot length: Mean length of a sample of seagrass shoots from the base of the shoot to its tip, measured either in situ or in samples returned to the lab

Seagrass shoot density: The number of seagrass shoots per unit seabed area

Seagrass above-ground biomass: Total dry mass of above-ground seagrass tissue (shoots and leaves) within a sample of specified size

Seagrass below-ground biomass: Total dry mass of below-ground seagrass tissue (roots and rhizomes) within a sample of specified size

Appendix - Additional information

A1. Applications

This table provides examples of applications of this EOV, including, contribution to other essential variable frameworks, multilateral environmental agreements, contribution to indicators and GOOS applications

EOV		Seagrass cover and composition
CORRESPONDING ESSENTIAL VARIABLES	ECV	Marine habitats
	EBV	Genetic composition: Allelic and genotypic diversity, inbreeding indices Species populations: Species occurrences, species abundances Species traits: Phenology of growth and flowering, shoot turnover rate, time to first asexual reproduction, seed dormancy Community composition: community diversity (species and/or phylogenetic diversity) and composition, community functional (trait) diversity and composition Ecosystem structure: Habitat structure (canopy height and density, rhizome mass and density) Ecosystem functioning: Primary production, carbon cycling and storage/sequestration (above and below-ground biomass, sediments), nitrogen cycling and storage, physical structure, secondary production of associated animals
GLOBAL INDICATORS EOV CAN CONTRIBUTE	**SDG**	Sustainable Development Goal 14: Target 14.1: Reduce marine pollution (seagrasses as water quality sentinels); Target 14.2: Protect and restore ecosystems (seagrass habitats as major coastal ecosystems); Target 14.3: Reduce ocean acidification (seagrasses as carbon sinks[1]); Target 14.4: Sustainable fishing (seagrasses as essential fish habitat, fishery nurseries); Target 14.5: Conserve coastal and marine areas; Target 14.a: Increase scientific knowledge, research and technology for ocean health; Target 14.b: Support small-scale fishers (artisanal harvesting of fish, shellfish in seagrass habitats) Target 14.7: Increase the economic benefits from sustainable use of marine resources.
	CBD GBF	Goal A: Protect and Restore Goal B: Prosper with Nature Target 1: Plan and Manage all Areas To Reduce Biodiversity Loss Target 2: Restore 30% of all Degraded Ecosystems Target 6: Reduce the Introduction of Invasive Alien Species by 50% and Minimize Their Impact Target 9: Manage Wild Species Sustainably To Benefit People Target 21: Ensure That Knowledge Is Available and Accessible To Guide Biodiversity Action

	CLIMATE	UNFCCC: Nationally Determined Contributions: seagrass extent US Global Change Research Program: Climate indicators: Marine species distribution
	RAMSAR	Target 8: National wetland inventories have been either initiated, completed, or updated and disseminated and used for promoting the conservation and effective management of all wetlands; Target 11: Wetland functions, services and benefits are widely demonstrated, documented and disseminated; Target 12: Restoration is in progress in degraded wetlands, with priority to wetlands that are relevant for biodiversity conservation, disaster risk reduction, livelihoods and/or climate change mitigation adaptation.
	UN Ocean Decade	Outcome 2: A healthy and resilient ocean where marine ecosystems are understood, protected, restored and managed. Outcome 3: A productive ocean supporting sustainable food supply and a sustainable ocean economy. Outcome 5: A safe ocean where life and livelihoods are protected from ocean-related hazards. Outcome 7: An inspiring and engaging ocean where society understands and values the ocean in relation to human wellbeing and sustainable development.
GOOS APPLICATIONS		Ocean health

A2. Additional supporting material and literature

Suggested literature

Other material

A3. Readiness level assessment

Essential Ocean Variable Specification Sheet

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